



Standard Practice for Verification and Classification of Extensometers¹

This standard is issued under the fixed designation E 83; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This practice covers procedures for the verification and classification of extensometer systems, but it is not intended to be a complete purchase specification. The practice is applicable only to instruments that indicate or record values that are proportional to changes in length corresponding to either tensile or compressive strain. Extensometer systems are classified on the basis of the magnitude of their errors.

1.2 Because strain is a dimensionless quantity, this document can be used for extensometers based on either SI or US customary units of displacement.

NOTE 1—Bonded resistance strain gages directly bonded to a specimen cannot be calibrated or verified with the apparatus described in this practice for the verification of extensometers having definite gage points. (See procedures as described in Test Methods E 251.)

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 ASTM Standards:

E 6 Terminology Relating to Methods of Mechanical Testing²

E 21 Test Methods for Elevated Temperature Tension Tests of Metallic Materials²

E 251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages²

3. Terminology

3.1 **Definitions**—In addition to the terms listed, see Terminology E 6.

3.1.1 **extensometer**—a device for sensing strain. An extensometer may be one of two types:

3.1.1.1 Self-contained type.

3.1.1.2 Non-self-contained type (that requires an auxiliary device (for example, recorder, digital readout, computer display, etc.)) for readout of strain values.

Discussion—For some extensometers the gage length is fixed, while for others the gage length is variable and must be set or determined

before the linear strain can be calculated.

3.1.2 **extensometer system**—a system for sensing and indicating strain.

3.1.2.1 **Discussion**—The system may be an extensometer of the self-contained type or the combination of an extensometer of the non-self-contained transducer type with a suitable readout device.

3.1.3 **compressometer**—a specialized extensometer used for sensing negative or compressive strain.

3.1.4 **deflectometer**—a specialized extensometer used for sensing of extension or motion, usually without reference to a specific gage length.

3.1.5 **calibration factor**—the factor by which the change in extensometer reading must be multiplied to obtain the equivalent strain.

3.1.5.1 **Discussion**—For any extensometer, the calibration factor is equal to the ratio of change in length to the product of the gage length and the change in the extensometer reading. For direct-reading extensometers the calibration factor is unity.

3.1.6 **calibration**—a determination of the calibration factor for a system using established procedures.

3.1.7 **verification**—a determination that a system meets the requirements of a given classification after calibration according to established procedures.

3.1.8 **verification apparatus**—a device for verifying extensometer systems.

3.1.8.1 **Discussion**—This device is used to simulate the change in length experienced by a test specimen as a result of the applied force. The extensometer may either be attached directly to the mechanism or interfaced with it in a manner similar to normal operation (that is, possibly without contact for some optical extensometers).

3.1.9 **error, in extensometer systems**—the value obtained by subtracting the correct value of the strain from the indicated value given by the extensometer system.

4. Verification Apparatus

4.1 The apparatus for verifying extensometer systems shall provide a means for applying controlled displacements to a simulated specimen and for measuring these displacements accurately. It may consist of a rigid frame, suitable coaxial spindles, or other fixtures to accommodate the extensometer being verified, a mechanism for moving one spindle or fixture axially with respect to the other, and a means for measuring accurately the change in length so

¹ This practice is under the jurisdiction of ASTM Committee E-28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.01 on Calibration of Mechanical Testing Machines and Apparatus.

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² Annual Book of ASTM Standards, Vol 03.01.

produced,³ or any other device or mechanism that will accomplish the purpose equally well. The mechanism provided for moving one spindle relative to the other shall permit sensitive adjustments. The changes in length shall be measured, for example, by means of an interferometer, calibrated standard gage blocks and an indicator, a calibrated micrometer screw, or a calibrated laser measurement system. If standard gage blocks and an indicator, or a micrometer screw, are used, they shall be calibrated and their limits of accuracy and sensitivity stated. The errors of the verification apparatus shall not exceed one third of the permissible error of the extensometer.

4.2 The verification apparatus shall be calibrated at intervals not to exceed two years.

NOTE 2—He-Ne laser interferometer measurement systems based on the 0.633 μm wavelength line are considered to be primary-based displacement standards and do not require recalibration.⁴

4.3 If the verification apparatus is to be used to verify extensometers used for bidirectional tests, the errors of the verification apparatus should be measured in both directions of travel so as to include any backlash present.

5. Verification Procedure for Extensometer Systems

5.1 *General Requirements*—The verification of an extensometer system should not be done unless the components of the system are in good working condition. Thoroughly inspect all parts associated with smooth operation of the instrument to ensure there are no excessively worn components. Repair or replace parts as necessary. Remove any dirt particles which may have accumulated through normal use of the instrument. Verification of the system shall be performed whenever parts are interchanged or replaced.

5.1.1 The verification of an extensometer system refers to a specific extensometer used with a specific readout device. Unless it can be demonstrated that autographic extensometers and recorders of a given type may be used interchangeably without introducing errors that would affect the classification of the extensometer, the extensometer shall be calibrated with the readout device with which it is to be used.

5.1.2 Prior to the initial verification, the extensometer should be calibrated according to the manufacturer's instructions or established procedures. The calibration procedure may include adjustment of span or determination of calibration factor, or both.

5.2 *Gage Length Measurement Method*—Measure the gage length of self-setting instruments by either the direct or indirect method.

NOTE 3—The following is an example of an indirect method. Set the extensometer to its starting position and mount it on a soft rod of the typical specimen size or diameter. After the extensometer is removed, measure the distance between the marks left by the gage points (or knife edges). If there are four or more gage points, take the average of the

individual lengths as the gage length. The differences between individual measurements shall not exceed the tolerance given for the class of extensometer. If there are two gage points (or knife edges), but on opposite sides of the specimen, attach the extensometer twice rotating it 180° with respect to the rod. Take the average of the lengths thus established on each side of the rod as the gage length.

5.2.1 Make two measurements of the gage length. Determine and record the error from each measurement, which is the difference between the measured gage length and the specified gage length, expressed as a percent of the specified gage length.

5.2.2 For extensometer devices that do not have a self-setting gage length during use, such as deflectometers and some high-temperature tensile or creep extensometers, verification run errors should be calculated using the gage length for which the device is used. Separate classifications should be established for each gage length or range used.

5.2.3 Some extensometers have the capability to measure the gage length set by or chosen by the user. If this measurement is used in the calculation of strain, then it is the inherent measurement accuracy that is the important factor rather than the error between the chosen length and the actual.

NOTE 4—An example of an extensometer that is described by 5.2.3 is an optical extensometer that measures the position of "flags" attached to the test specimen. The flags are positioned at the approximate required gage length and the instrument measures the position of the flags (the actual gage length) before and after the specimen is stressed. Although this kind of device usually has a stated accuracy of gage length, it must be verified by either direct or indirect methods at the appropriate gage lengths.

5.3 *Position of Extensometer*—Carefully position the extensometer on or interface it to the verification device in the same manner as it is normally used for typical specimens. For extensometers that attach directly to the specimen, the verification device should allow attachment to pieces that are similar to the specimen on which the extensometer will be attached.

5.4 *Temperature Control*—Verify the extensometer at approximately the same temperature at which it will be used. Allow sufficient time for the verification device and extensometer to reach satisfactory temperature stability. Maintain temperature stability by excluding drafts throughout the subsequent verification. Record the temperature during each verification run.

NOTE 5—Extensometers used for high-temperature testing may be verified at ambient temperature to insure proper operation, but fixtures should be designed to verify performance at the actual test temperature. This is especially true with optical extensometers which may be adversely affected by air density changes associated with thermal gradients and turbulence, environmental chamber windows, or specimen changes due to the environment. See Appendix X2.

5.5 *Method of Reading*—Read the instrument or, in the case of an autographic extensometer, measure the record in the same manner as during use.

5.5.1 For extensometer with dial micrometers or digital readouts, the readings shall be recorded. Extensometers that use autographic methods shall have their charts read and recorded using a suitable measuring device, such as a vernier or dial caliper. The use of an optical magnifying device is recommended when reading and measuring autographic records.

³ A review of some past, current, and possible future methods for calibrating strain measuring devices is given in the paper by Watson, R. B., "Calibration Techniques for Extensometry: Possible Standards of Strain Measurement," *Journal of Testing and Evaluation*, JTEVA, Vol. 21, No. 6, November 1993, pp. 515-521.

⁴ A letter from NIST (National Institute of Standards and Technology) is available for reference. Request RR:E 28-1013 from ASTM Headquarters.

NOTE 6—When autographic extensometer systems are used, care should be taken to minimize errors introduced by variances in the graph paper. These errors can be due to dimensional changes from reproduction or humidity changes. Direct measurement of the trace soon after it was made eliminates the graph paper errors and is desirable for systems verification.

NOTE 7—If an extensometer is equipped with a dial micrometer, it may be necessary to lightly tap the dial micrometer to minimize the effects of friction and to ensure that the most stable and reproducible readings are obtained. If the dial micrometer is tapped during the verification procedure, include this information in the report.

5.6 Zero Adjustment—After temperature stability has been achieved, displace the verification device (with extensometer in the test position) to a slightly negative value and return to zero. If the reading does not return to zero, adjust and repeat the procedure until the reading does return to zero.

5.7 Number of Readings—Observe the reading of the extensometer for at least ten displacement values spaced at approximately equal increments over the full verification range of the extensometer.

5.7.1 Extensometers need not be verified beyond the range over which they will be used. Multi-range (multiple-magnification) extensometers shall be verified for each range to be used.

NOTE 8—If the connection between the gage points attached to the specimen and the indicating device is made through geared wheels or micrometer screws, relatively large periodic errors may exist which might not be disclosed by this overall procedure. For such extensometers it may be necessary to take additional readings within one turn of any geared wheel, micrometer screw, or the travel of one tooth of any meshing gear.

5.8 Number of Runs—Take at least two complete sets of extensometer readings for the same changes of length. After the first run, an operation that simulates normal operation should be used to check repeatability. An extensometer that attaches directly to the specimen should be removed and then reattached to the verification device between runs. An extensometer that does not attach directly to the specimen should be moved away from the verification device (or the device moved away from the extensometer) to simulate the changing of test specimens.

5.9 Direction of Verification Displacement:

5.9.1 Extensometers Used for Unidirectional Tests—Extensometers used for unidirectional tests (for example, tension tests) shall be verified by applying displacement in the direction of testing normally used. If start-up backlash is evident, the verification device (with extensometer in place) may be displaced to a slightly negative value and returned to zero before each run.

NOTE 9—This verification procedure does not measure the initial backlash in the extensometer that may appear after it is first attached to the specimen. If the extensometer is used with open or closed loop-type test equipment in load control, the users should disregard readings taken during the initial part of the loading curve. If the extensometer is used with closed loop test equipment in strain control, the backlash could result in large tension or compression loads during the initial part of the loading curve.

5.9.2 Extensometers Used for Bidirectional Tests—Extensometers used for bidirectional tests (for example, hysteresis tests, fatigue tests, etc. See Appendix X3.) shall be verified by applying both increasing and decreasing values of displacement over the total range of intended use. Displace

the verification device (with extensometer in place) to a slightly negative value and return to zero before each run. During each run, displace the extensometer to the maximum positive value, then to the maximum negative value, and then back to zero, stopping at each verification point along the way in each direction.

5.10 Determination of Errors—Calculate the error of the extensometer system for each change in length of the verification apparatus. Errors are based on net values from the zero point to each successive verification point, not on increments between verification points.

6. Classification of Extensometer Systems

6.1 Classify extensometer systems in accordance with the requirements as to maximum error of strain indicated by the extensometer system shown in Table 1. The maximum allowable error in each class is the fixed error or the variable error, whichever is greater. The fixed error will establish the maximum allowable error for readings near zero, but the variable error may establish the maximum allowable error for readings near full scale. Two examples of this procedure are presented in Appendix X1. In addition, the gage length error for self-setting extensometers shall not exceed the greater of the values shown in Table 1.

6.2 Separate classifications may be established for different ranges of multi-range (multiple-magnification) extensometer systems.

7. Verification of Multiple Strain Readouts

7.1 When an extensometer is to be used with two or more readout devices (for example, a graphic recorder and a digital readout), steps must be taken to assure that errors are not introduced by interactions (mechanical or electrical) between the readout devices or between the readouts and the extensometer, and that values from each readout device satisfy appropriate performance criteria. (Different accuracy classifications could be given to the systems using different readout devices.) This can best be accomplished by verifying each system (extensometer and readout device) individually and also in combinations that would be used simultaneously. As an alternative, after individual verifications have been made, the combination can be checked at 3 points (about 20, 50, and 90 % of full scale range are recommended); and, if values for each system do not differ from the individual verification values by more than 20 % of the class tolerance, the combined system shall be considered to meet the same

TABLE 1 Classification of Extensometer Systems

Classification ^a	Error of Strain ^a not to Exceed the Greater of:		Relative Error of Gage Length (max %) (See 5.2)
	Fixed Error, (in./in. mm/mm)	Relative Error, (% of strain)	
Class A	0.00002	±0.1	±0.1
Class B-1	0.0001	±0.5	±0.25
Class B-2	0.0002	±0.5	±0.5
Class C	0.001	±1	±1
Class D	0.01	±1	±1
Class E	0.1	±1	±1

^a Strain of Extensometer System—Ratio of applied extension to the gage length.

^b Class A classification is very difficult to achieve at short (25 mm or less) gage lengths, so the commercial availability of an extensometer system that meets this requirement may be very limited or nonexistent.

requirements as the individual systems. If readout devices are always used in combination, individual verifications are not required when the combined system is verified as a unit.

8. Verification of Data Acquisition Systems

8.1 Extensometer systems in which strain values are indicated on displays or printouts of data acquisition systems, be they instantaneous, delayed, stored or retransmitted, which are verified in accordance with the provisions of Section 5 and classified in accordance with the provisions of Section 6, shall be deemed to comply with this practice.

9. Time Interval Between Verifications

9.1 It is recommended that extensometer systems be verified annually unless more frequent verification is required to comply with product or customer specifications. In no case shall the time interval between verifications exceed 18 months unless an extensometer is being used on a long-time test running beyond the 18-month period. In such cases, the extensometer system shall be verified immediately after completion of the test. (See Note 11.)

9.1.1 An extensometer system shall not be used after an adjustment or repair that could affect its accuracy without first verifying its accuracy utilizing the procedure described in this practice.

NOTE 10—If a test is expected to last more than 18 months, it is recommended that the extensometer system be verified immediately before as well as upon completion of the test.

10. Accuracy Assurance Between Verifications

10.1 Some product-testing procedures may require daily, weekly, or monthly spot checks to ascertain that an extensometer, recorder, or display, etc., or combinations thereof etc., are capable of producing accurate strain values between the verifications specified in Section 9. Spot checks may be performed on ranges of interest or at strain levels of interest utilizing a verification device that complies with Section 4 for the strain level(s) at which the spot checks are made.

10.2 Check the extensometer gage length (see 5.1).

10.3 Make spot checks of extensometer readings at approximately 10 and 50 % of a range unless otherwise agreed upon or stipulated by the material supplier or user.

10.4 The extensometer gage length and strain measurement errors shall not exceed the allowable errors at the spot check points for the specified class of extensometer. Should errors be greater than allowable at any of the spot check points, the extensometer system is to be completely verified immediately.

10.5 When spot checks are made, a clear, concise record must be maintained as agreed upon between the supplier and

the user. The record shall contain gage length and spot check test data; the name, serial number, verification date, verification agency of the verification device(s) used to make spot checks; the name of person making the spot check; and documentation of the regular verification data and schedule.

10.6 The extensometer system shall be considered verified up to the date of the last successful spot check verification provided that the extensometer system is verified in accordance with Section 5 on a regular schedule in accordance with Section 9. Otherwise, spot checks are not valid.

11. Report

11.1 The report shall include the following:

11.1.1 Method of gage length verification used.

11.1.2 Serial numbers and names of the manufacturers of all apparatus used in verifying the extensometer system.

11.1.3 Serial number and name of the manufacturer of the extensometer verified, or if it is an extensometer system composed of separable components, the serial number and manufacturer of each component of the systems verified.

11.1.4 Gage length of the extensometer. For variable gage length extensometers, state the gage lengths verified.

11.1.5 Temperature of the extensometer during verification.

11.1.6 Complete record of the readings of the extensometer and of the verification apparatus.

11.1.7 Calibration factor.

11.1.8 Error in gage length for each measurement of gage length.

11.1.9 Error of the extensometer system for each extensometer reading.

11.1.10 Class of the extensometer system. If separate classifications are established for various ranges, report the range (or magnification) and strain values associated with each classification.

11.1.11 If the classification applies to bidirectional testing, it shall be so stated. Otherwise, the classification shall be considered to be unidirectional in the direction of normal use (that is, opening for tension testing, closing for compression testing, etc.).

11.1.12 The name of the person performing the classification and the date it was performed.

11.2 Information to be available upon request shall include the following:

11.2.1 A statement indicating how, by whom, and when the most recent calibration of the apparatus used in verifying the extensometer system was made.

11.2.2 A statement of the errors of the verification apparatus.

11.2.3 Position of the extensometer during verification.

11.2.4 Method of interfacing or attaching the extensometer to the verification device.

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLE OF PROCEDURE FOR VERIFICATION AND CLASSIFICATION OF EXTENSOMETERS

X1.1 The data obtained for a typical indicating extensometer during calibration are given in the first four columns of Table X1.1. The results calculated from these data are given in columns 5 to 8, inclusive, of Table X1.1.

X1.2 The indicated strains, obtained by multiplying each change in extensometer reading by the calibration factor are given in Table X1.2. The error for each change in extensometer reading is also given in Table X1.2 and is plotted in Fig. X1.1.

X1.3 The calibration factor given in Table X1.1 was

calculated from the results in columns 5 to 8, inclusive, of Table X1.1 by the method of least squares. The calibration factor is proportional to the slope of the line drawn to represent the observed points and could have been determined from a graph.

X1.4 Since the maximum error given in columns 5, 6, and 7 of Table X1.2 does not exceed 0.00005, the extensometer is classified as a Class B-1 extensometer.

X1.5 The data for a typical autographic extensometer are given in Fig. X1.2.

TABLE X1.1 Calibration Data for a Typical Extensometer

NOTE 1—Calibration apparatus used Johansson Blocks with error not more than 0.000004 in. (0.1 μ m), indicator sensitivity 0.000005 in. (0.1 μ m)
NOTE 2—Measured gage length = 1.000 in. (25.40 mm)

Change in Length, in. (mm)	Extensometer Reading, Divisions			Change in Strain, in./in. (m/m)	Change in Extensometer Reading		
	Run No. 1	Run No. 2	Run No. 3		Run No. 1	Run No. 2	Run No. 3
1	2	3	4	5	6	7	8
0.00000 (0.0000)	-0.09	-0.015	-0.055	0.00000	0.000	0.000	0.000
0.00100 (0.0254)	0.245	0.32	0.275	0.00100	0.335	0.335	0.33
0.00200 (0.0508)	0.57	0.65	0.60	0.00200	0.66	0.665	0.655
0.00300 (0.0762)	0.895	0.97	0.92	0.00300	0.985	0.985	0.975
0.00400 (0.1016)	1.22	1.295	1.25	0.00400	1.31	1.31	1.305
0.00500 (0.1270)	1.555	1.625	1.58	0.00500	1.645	1.64	1.635
0.00600 (0.1524)	-0.08	-0.08	-0.095
0.00700 (0.1778)	0.265	0.26	0.25	0.00600	1.99	1.98	1.98
0.00800 (0.2032)	0.60	0.595	0.585	0.00700	2.325	2.315	2.315
0.00900 (0.2286)	0.92	0.915	0.905	0.00800	2.645	2.635	2.635
0.01000 (0.2540)	1.25	1.24	1.23	0.00900	2.975	2.96	2.96
	1.58	1.565	1.555	0.01000	3.305	3.285	3.285

Calibration factor = 0.003033

TABLE X1.2 Errors of Extensometer Readings

Change in Strain, in./in. (m/m)	Indicated Strain			Error		
	Run No. 1	Run No. 2	Run No. 3	Run No. 1	Run No. 2	Run No. 3
1	2	3	4	5	6	7
0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000
0.00100	0.00102	0.00102	0.00100	0.00002	0.00002	0.00000
0.00200	0.00200	0.00202	0.00199	0.00000	0.00002	-0.00001
0.00300	0.00299	0.00299	0.00296	-0.00001	-0.00001	-0.00004
0.00400	0.00397	0.00397	0.00396	-0.00003	-0.00003	-0.00004
0.00500	0.00499	0.00497	0.00496	-0.00001	-0.00003	-0.00004
0.00600	0.00604	0.00601	0.00601	0.00004	0.00001	0.00001
0.00700	0.00705	0.00702	0.00702	0.00005	0.00002	0.00002
0.00800	0.00802	0.00799	0.00799	0.00002	-0.00001	-0.00001
0.00900	0.00902	0.00898	0.00898	0.00002	-0.00002	-0.00002
0.01000	0.01002	0.00996	0.00996	0.00002	-0.00004	-0.00004

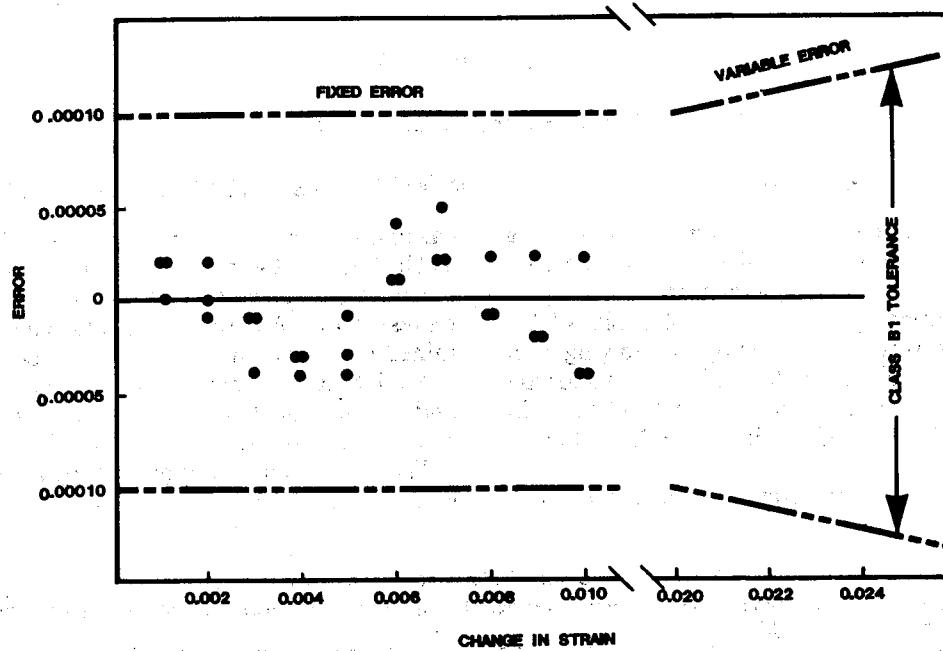
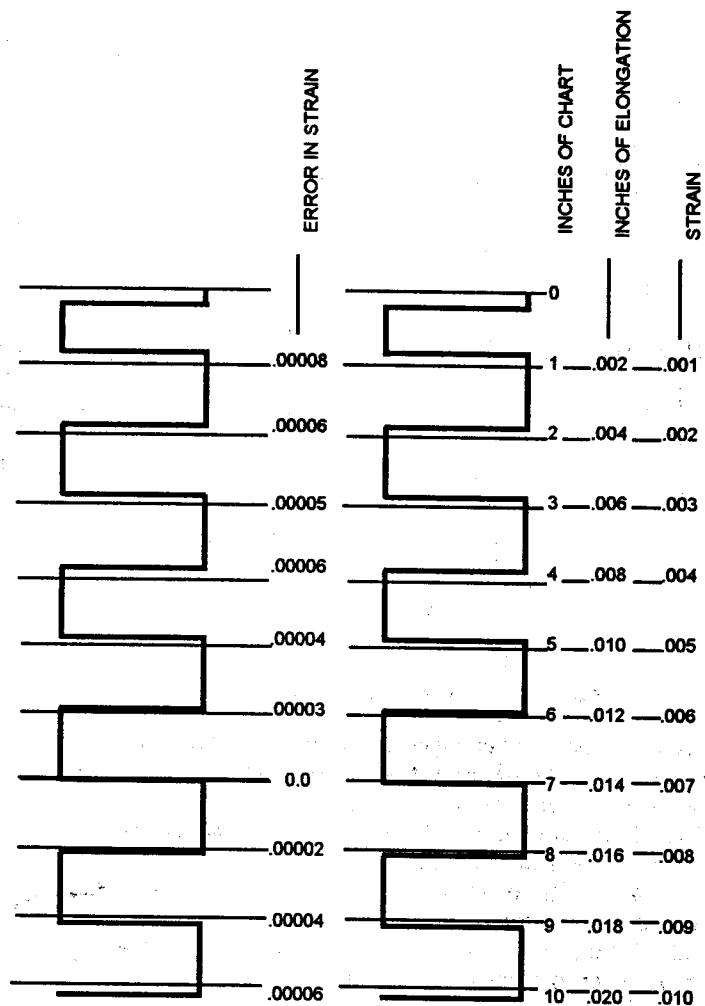


FIG. X1.1 Error for Each Change in Extensometer Reading

1. **METHOD OF VERIFICATION OF CALIBRATION**
Extensometer Comparator
2. **SOURCE OF CALIBRATION APPARATUS**
Comparator - ABC Co.
Gage Blocks - XYZ Co.
Optimeter - John Doe Co.
3. **VERIFICATION OF CALIBRATION APPARATUS**
Gage Blocks - National Institute of Standards and Technology. - 1/3/95
Optimeter - National Institute of Standards and Technology - 1/3/95
4. **ERRORS OF CALIBRATION APPARATUS**
Max. Error 0.00001"
5. **IDENTIFICATION OF EXTENSOMETER**
John Brown Co. Model T-1M Serial No. 1683
6. **GAGE LENGTH OF EXTENSOMETER - 2.000"**
7. **POSITION OF EXTENSOMETER DURING CALIBRATION**
Attached to 0.500" Spindle with Axis Vertical
8. **TEMPERATURE OF EXTENSOMETER**
During Calibration - 70 F
9. **METHOD OF ATTACHMENT TO CALIBRATION APPARATUS**
As Per Manufacturer's instructions for service use
10. **RECORDS OF READINGS**
As per graph
11. **CALIBRATION FACTOR - 0.001**
12. **ERROR OF EXTENSOMETER**
Error 0.00008 Strain
(At 0.001 Strain)
13. **CLASS OF EXTENSOMETER - B1**
14. **DATE OF VERIFICATION - 5/3/95**



NOTE—Error in strain is calculated by measuring the error in chart length and multiplying by the calibration factor.

FIG. X1.2 Typical Record and Report for Extensometers Verified on Autographic Recorders

X2. TEMPERATURE EFFECTS ON EXTENSOMETER CLASSIFICATION

X2.1 Using an extensometer on a test specimen at a temperature other than the temperature at which the verification was performed can cause errors in the strain reading. The source of these errors varies with the type of extensometer being used. It may be due to a shift in the null point of the device, a change in span, or an error in the gage

length.

X2.2 Some common typical sources of error are as follows:

X2.2.1 Clip-On Type Extensometers:

X2.2.1.1 Dimensional changes due to thermal effects giving rise to errors in zero, span, and gage length,

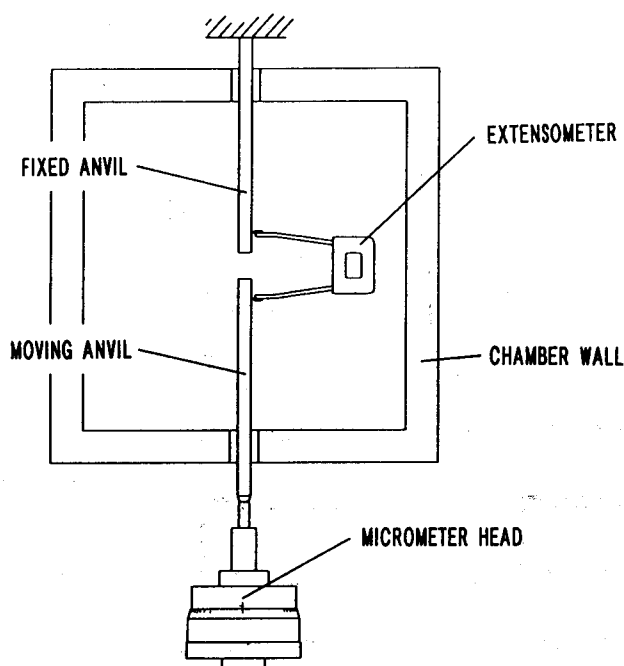


FIG. X2.1 Schematic of Test Set-Up

X2.2.1.2 Sensitivity changes as a function of temperature of the transducer being used (that is, strain gages, capacitive devices, LVDTs, etc.) giving span errors,

X2.2.1.3 Shifts in the null point of the transducer being used as a function of temperature,

X2.2.1.4 Sensitivity changes as a function of dielectric changes of the environment, and

X2.2.1.5 Sensitivity changes as a function of modulus change in extensometer arms or element.

X2.2.2 Non-Contact Type Extensometers:

X2.2.2.1 Refraction effects due to windows, temperature gradients, or turbulence can cause errors in some type extensometers (for example, scanning beams measuring distance between flags),

X2.2.2.2 Loss of transparency in windows can reduce accuracy,

X2.2.2.3 Changes in speed of light, if not corrected, will cause errors in some laser techniques,

X2.2.2.4 Changes in the surface of the specimen due to oxidation, frosting, corrosion, etc., will cause problems with some techniques, and

X2.2.2.5 Radiation emitted by high-temperature specimens or heaters may affect the performance of various optical extensometers.

X2.3 Since there are a wide variety of new extensometry instruments based on new technology, it is impossible to predict or correct, or both, for all possible sources of error when using these methods at high or low temperatures. The only prudent approach is to perform a Practice E 83 type of verification within the environment to be used. It is recommended that the same environmental chamber (furnace or cryostat) be used for the verification that is being used for the material test. This will insure similar thermal and optical conditions exist and, hence, similar effects on the strain measurement should be observed.

X2.4 Examples of methods that could be employed for verification are as follows: (Also see Test Methods E 21,

Paragraph 5.4.1).

X2.4.1 *Environmental Effects on Span*—The schematic below shows a clip-on extensometer in an environmental chamber mounted on a split specimen attached to a micrometer head. Although it may be difficult to establish effects on zero (null point) or gage length accuracy, this setup can be used to measure any changes to the span of the device.

X2.4.2 *Effects on the Null Point*—A material of zero or known expansion coefficients can be used to measure the effects of temperature on the null or zero of the extensometer. The device is either mounted on or focused toward (for optical non-contact extensometers) the "dummy" specimen. The known effects of temperature (in the absence of stress) on the material's dimension can be compared against the measured effect from the extensometer to give a measurement of the change in zero.

X2.4.3 Effects on Gage Length Accuracy:

X2.4.3.1 This quantity is more difficult to determine since common methods (as described in this practice) for determining accuracy of gage length are difficult to apply at high or low temperatures.

X2.4.3.2 For example, if an extensometer is "clipped" on a specimen that was immersed in a cryogenic liquid, the accuracy of the gage length setting could be determined at room temperature by conventional methods. The actual low-temperature gage length would be different since the material would change in length according to its coefficient of expansion characteristics. If these are known and the temperature is known, then the low-temperature gage length can be calculated.

X2.4.3.3 If the null and span characteristics of the extensometer are known, then the change in output of the extensometer (attached to the specimen) as the temperature is lowered will give a direct reading of the thermal characteristics of the material and this output can be used to determine the new gage length.

X2.5 Another possible approach for non-contact type systems is the use of reference specimens. Some of these extensometers measure the distance between "flags" on the specimen at zero load as the gage length. The accuracy of the gage length is dependent on the accuracy of the instrument and does not rely on precise placement of the flags. A possible method to verify this at high temperature is the use of a precision reference specimen with known gage length (placement of marks or flags) and known thermal mechanical properties. This specimen is then placed in the environmental chamber, and the environmental and optical conditions to be used in the test can be reproduced. The gage length can be calculated from the known properties of the reference specimen and compared with the measurement.

X2.6 This appendix is not intended to be a detailed test procedure for verification of the classification of extensometers as a function of all environments. It should be used as a guide to make the user aware of possible errors in strain that result from environmental effects. Manufacturers of extensometers should provide performance characteristics of their instruments under typical operating test conditions. Although this information is seldom adequate to allow the user to ignore errors due to their specific test conditions, it can be used as a starting point for further analysis.

X3. FREQUENCY EFFECTS ON THE CLASSIFICATION OF EXTENSOMETERS

X3.1 The usable bandwidth of extensometers is a function of both mechanical and electrical characteristics. It is naive to perform a static verification as described in Practice E 83 and run dynamic (cyclic) testing and assume that the classification remains unchanged. In general, both the amplitude and phase of the instrument may change as a function of frequency effects. Some examples follow.

X3.1.1 *Mechanical Effects*—If the specimen extensometer system approaches a resonance, there will be shifts in the phase between the input and the resulting strain as well as errors in the amplitude reading. The error in strain amplitude approaching a resonance will be positive, will peak at the resonance (for underdamped systems) and will become a negative error beyond the resonant point. This effect depends not only on the resonant frequency but the Q of the resonance. Extensometers that contain large mechanical elements may have inertial effects which at high frequencies cause forces on the attachment points to the specimen. These forces can lead to slipping of the extensometer which will give errors in strain.

X3.1.2 *Electronic Effects*—Most extensometer systems include electronics which have bandwidths determined by the detail of the design. These should be specified by the manufacturer. They result from the following characteristics:

X3.1.2.1 Response of the readout device. For example, if a chart recorder or XY plotter were being used, then the pen response might be the limiting factor; or if a digital readout device is used, they are often filtered to avoid digit instability. This filter will have a roll-off frequency, which may be the limiting factor of the bandwidth.

X3.1.2.2 For digital instruments the digital sampling rate will affect the bandwidth. Aliasing can also be a factor in digital systems.

X3.1.2.3 On the opposite end of the spectrum long-term drift characteristics must be considered for extensometers to be used in long-term creep testing.

X3.2 *Qualitative Test of Dynamic Performance:*

X3.2.1 There are a number of methods that can be used to check the dynamic performance of an extensometer. These methods, if carefully implemented, would give quantitative information on the dynamic effects on the accuracy

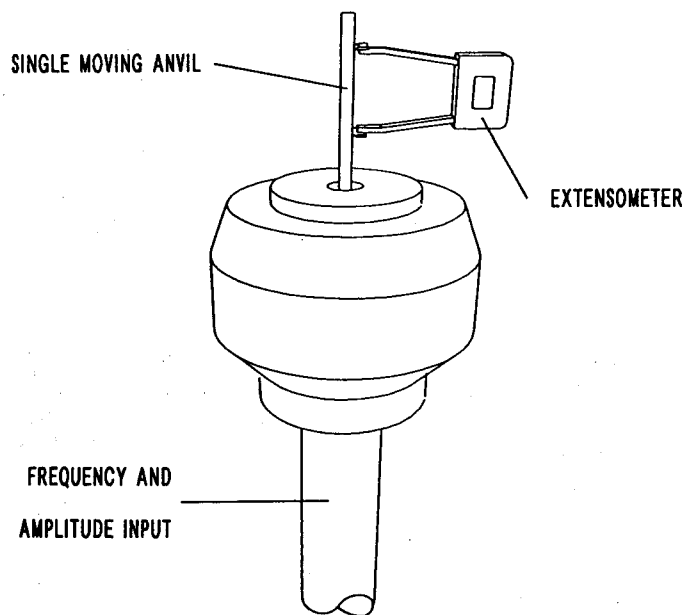


FIG. X3.1 Extensometer on a Single Moving Anvil

of the extensometer. This appendix is not intended to provide specific procedures for a dynamic calibration of an extensometer. An extensometer of known dynamic properties can be used in parallel with the device in question, and a comparison of the results can be made as a function of frequency. A strain-gaged specimen can be used as a reference, or a specimen with known properties could be used to verify the extensometer results.

X3.2.2 It is recommended, however, that as an absolute minimum the test illustrated in Fig. X3.1 be used to check the extensometer over the frequency range of interest. The test conditions (frequency and amplitude) should be applied to the extensometer attached to a single anvil as shown. Ideally, this test should result in zero output over the performance range of interest. Any output under these test conditions will likely cause deviations in the accuracy of the extensometer system as determined by the static verification described in Practice E 83.

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